

## **APPENDIX E**

## **BMP COST CALCULATIONS**

This document describes the cost-effectiveness of urban and agricultural best management practices (BMPs) that reduce nutrients.

### **On-Site Wastewater Treatment and Disposal System (OWTDS) BMP Cost Calculations**

#### **I. Connecting OWTDS to Sewer Districts**

According to DNREC's Financial Assistance Branch (personal communication, 2007), the average cost of constructing a sewer system is \$8,500 per equivalent dwelling unit (EDU). In the future, this cost is expected to increase to \$10,000/EDU. The debt service, or cost of financing these systems, at roughly an average 2% rate is currently \$1,867/EDU and will be \$2,194/EDU for future septic eliminations and sewer connections. Additionally, system owners must pay for the final septic system pump-out, crushing and filling the tank, and the connection costs associated with building the lateral line running from the building to the right of way. These three expenditures together run approximately \$1,000/EDU. Finally, operation and maintenance (O&M), including repair fees, of roughly \$200 per EDU per year will also be added to these values for an average 20 year lifespan of a connection (DNREC Financial Assistance Branch, personal communication, 2007) (Table 1).

<b>Table 1. OWTDS Elimination Costs</b>		
	<b>Past Conversions</b>	<b>Future Conversions</b>
<b>Construction of sewer system</b>	\$8,500/EDU	\$10,000/EDU
<b>Debt service</b>	\$1,867/EDU	\$2,194/EDU
<b>Additional expenditures</b>	\$1,000/EDU	\$1,000/EDU
<b>Operation and Maintenance (over 20 year lifespan)</b>	\$4,000/EDU	\$4,000/EDU
<b>TOTAL</b>	<b>\$15,367/EDU</b>	<b>\$17,194/EDU</b>

#### **II. Holding Tank Inspection and Compliance Program**

The cost of pumping-out a 2,800 gallon holding tank averages around \$250 per system per pump-out (DNREC Small Systems Branch, personal communication, 2007). As a result of the holding tank inspection and compliance program, they have been shown to be pumped-out roughly 12 times a year. This information reveals that the owner of a single holding tank will spend \$3,000 each year. In addition to this cost, there is an annual inspection fee of \$60 per system (DNREC Small Systems Branch, personal communication, 2007), so that the total expenditure for holding tank inspection and compliance is \$3,060/system/year and over a 20 year lifespan the cost is \$61,200/system.

### **III. OWTDS Pump-outs**

The cost of pumping-out OWTDS ranges from \$185-200 per system, with an average cost of \$192.50 per system (DNREC Small Systems Branch, personal communication, 2007). It is proposed that septic systems be pumped once every three years and inspected during that time period as well. These proposed inspections will be performed by licensed inspectors at an estimated cost that ranges from \$200 to \$400 with an average cost of \$300 at the time of pump-out (DNREC Small Systems Branch, personal communication, 2007). The total cost of the OWTDS inspection and compliance program will cost the system owner \$164.17/system/year and over a 20 year lifespan this equals \$3,283.33/system.

### **IV. OWTDS Performance Standards**

Licensed installers and members of DNREC's Small Systems Branch (personal communication, 2007) revealed that the installation of best available technologies (BATs) to existing small (<2,500 gallon per day (gpd)) OWTDSs for advanced nitrogen removal would cost between \$3,500 and \$6,000 per system with an average installation of \$4,750. These technologies are believed to last for approximately 20 years. These technologies require a service contract by a certified service provider with an estimated annual cost that ranges from \$150 to \$300, with an average cost of \$225/system/year. In addition, the systems will still require pump-outs, which costs \$64/system/year (DNREC Small Systems Branch, personal communication, 2007), and they will need periodic mechanical parts repaired, estimated to cost \$50/system/year and the electrical cost of running the systems is likely to also cost about \$50/system/year (DNREC Financial Assistance Branch, personal communication, 2007). Taking all of this into account, the total cost of this strategy is \$12,530/system.

## **Stormwater BMP Cost Calculations**

### **I. Wet and Dry Ponds**

Typical costs for retention basins were retrieved from Chapter 6.0, “Costs and Benefits of Storm Water BMPs,” of an EPA on-line document (EPA, 1999). In this document, it states that a retention basin treating a 50-acre residential site in 1999 costs about \$100,000, such that the cost per unit area was \$2,000/acre. All values reported in the document need to be divided by an adjustment factor to account for regional differences. Delaware falls in Region 2, which has a 0.90 adjustment factor (EPA, 1999). Thus, retention basins in Delaware in 1999 cost approximately \$2,222.22/acre. Using the average annual federal inflation rate for the time period of 1913-2007 (3.42%), the capital cost of Delaware retention basins in 2009 is \$2,982/acre. To this value, the annual operation and maintenance costs over a 25 year lifespan must be added. Operation and maintenance costs for retention basins were determined from New Castle County Department of Land Use’s guidance found in the document “Maintenance (Minor) and Replacement (Major) Costs for Stormwater Management Facilities Preliminary Guidance Version #6” (NCC, 2005). Maintenance costs for wet and dry ponds include the following:

<b>Table 2. Retention Pond Maintenance Costs</b>					
	<b>Frequency</b>	<b>Unit Cost for Wet Ponds</b>	<b>Unit Cost for Dry Ponds</b>	<b>Annual Cost for Wet Ponds (40 acres)</b>	<b>Annual Cost for Dry Ponds (20 acres)</b>
<b>Inspection</b>	2 times a year	\$800 per inspection	\$800 per inspection	\$1,600	\$1,600
<b>Sediment Removal with Forebay</b>	1 time over 10 years	Based on removal of 0.5 ft of 2,000 sq ft forebay	Based on removal of 0.5 ft of 1,000 sq ft forebay	\$2,200	\$1,120
<b>Erosion Repair</b>	1 time over 2 years	\$4,400	\$4,400	\$2,200	\$2,200
<b>Repair Low Spots in Berm</b>	1 time over 5 years	Based on 20 cy of repair	Based on 10 cy of repair	\$1,280	\$640
<b>Repair Barrel Leaks</b>	1 time over 5 years	\$1,250 per event	\$1,250 per event	\$250	\$250
<b>Mowing</b>	10 times a year	Based on 2 acres mowed @ \$300/acre	Based on 2 acres mowed @ \$300/acre	\$6,000	\$6,000

<b>Repair Animal Burrows</b>	1 time a year	\$200	\$200	\$200	\$200
<b>Spray for Cattails and Algae (Wet Ponds)</b>	2 times a year	\$465		\$930	
<b>Invasive Removal (Wet Ponds)</b>	1 time a year	\$3,000		\$3,000	
<b>Total Annual Cost</b>				\$17,660.00	\$12,010.00
<b>Total Cost per Acre</b>				<b>\$441.50</b>	<b>\$600.50</b>

Including all maintenance costs and dividing by the total acres assumed, the annual cost per acre for wet ponds is \$441.50/acre/yr and for dry ponds is \$600.50. Adding this to the regionally adjusted construction cost over the 25 year lifespan, the total cost for this strategy is \$14,019.50/acre for wet ponds and \$17,994.50/acre for dry ponds.

## **II. Infiltration Structures**

The 1999 construction costs of infiltration trenches and infiltration basins treating 5-acre commercial sites were averaged to represent the range of infiltration structures utilized as stormwater BMPs throughout Delaware. These costs were \$45,000 for trenches and \$15,000 for basins (EPA, 1999), which equates to \$9,000/acre and \$3,000/acre, respectively, and averages \$6,000/acre. Once adjusted for the regional variability in cost (0.90 factor), and inflated to 2009, this value becomes \$8,946.67/acre treated by infiltration structures. Annual O&M costs for infiltration structures were determined from New Castle County estimates (NCC, 2005) as follows:

<b>Table 3. Maintenance Costs for Infiltration Structures</b>					
	<b>Frequency</b>	<b>Unit Cost for Infiltration Basin</b>	<b>Unit Cost for Infiltration Trench</b>	<b>Annual Cost for Infiltration Basin (20 acres)</b>	<b>Annual Cost for Infiltration Trench (1 acre)</b>
<b>Inspection</b>	2 times a year	\$800 per inspection	\$200 per inspection	\$1,600	\$400
<b>Sediment Removal</b>	1 time over 10 yrs with forebay (basin) / 1 time over 2 yrs (trench)	Based on removal of 0.5 ft of 1,000 sq ft forebay	\$350 per event	\$1,120	\$175

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<b>Erosion Repair</b>	1 time over 2 years/ 1 time over 3 years (trench)	\$4,400	\$1,200	\$2,200	\$400
<b>Repair Low Spots in Berm</b>	1 time over 5 years	Based on 10 cy of repair		\$640	
<b>Repair Barrel Leaks</b>	1 time over 5 years	\$1,250 per event		\$250	
<b>Mowing</b>	10 times a year	Based on 2 acres mowed @ \$300/acre	Based on 200 sq ft mowed @ \$300/acre	\$6,000	\$110
<b>Repair Animal Burrows</b>	1 time a year	\$200		\$200	
<b>Total Annual Cost</b>				\$12,010.00	\$1,085.00
<b>Total Cost per Acre</b>				<b>\$600.50</b>	<b>\$1,085.00</b>

This produces an annual O&M cost of \$600.50/acre/yr for infiltration basins and \$1,085.00/acre/yr for infiltration trenches. This averages out to \$842.75 which when calculated over a 25 year lifespan and added to construction costs equals \$30,015.42/acre.

### III. Filtering Practices

The EPA on-line document reported that the construction costs for filtering practices in 1999 were \$35,000 - \$70,000, \$60,000 for bioretention facilities, and \$9,000 for filter strips for a 5-acre commercial site (EPA, 1999), which when averaged equates to \$8,700/acre. Once adjusted for the regional variability in cost (0.90 factor), and inflated to 2009, this value becomes \$13,083.31. The O&M costs reported by New Castle County for filtering practices (NCC, 2005) are as follows:

<b>Table 4. Filtering Practices Maintenance Costs</b>					
	<b>Frequency</b>	<b>Unit Cost for Bioretention</b>	<b>Unit Cost for Filter Strips</b>	<b>Annual Cost for Bioretention (1 acre)</b>	<b>Annual Cost for Filter Strips (1 acre)</b>
<b>Inspection</b>	2 times a year	\$200 per inspection	\$200 per inspection	\$400	\$400
<b>Sediment Removal</b>	1 time over 2 years/ 1 time over 3 years (filter strips)	\$350 per event	\$350 per event	\$175	\$117
<b>Erosion Repair</b>	1 time over 3 years	\$1,200	\$1,200	\$400	\$400
<b>Mowing</b>	8 times a year		Based on 2000 sq ft mowed @ \$300/acre		\$110
<b>Soil Amendments</b>	1 time a year	\$100	\$100	\$100	\$100
<b>Plant Maintenance</b>	1 time a year	\$400		\$400	
<b>Total Annual Cost</b>				\$1,475.00	\$1,127.00
<b>Total Cost per Acre</b>				<b>\$1,475.00</b>	<b>\$1,127.00</b>

The maintenance costs for bioretention facilities are \$1,475.00/acre and the maintenance costs for filter strips are \$1,127.00/acre. The average maintenance costs of these filtering practices are \$1,301.00/acre. Calculating the O&M costs over a 25 year lifespan and adding to construction costs provides a total cost of \$45,608.31/acre.

#### **IV. Biofiltration**

The EPA on-line document reported that the construction costs for biofiltration devices in 1999 were \$3,500 for a 5-acre commercial site (EPA, 1999), which equates to \$700/acre. This value must also be divided by the 0.90 adjustment factor to account for regional cost differences, which yields \$777.78/acre, and then adjusted to the 2009 value, \$1,052.68/acre. The annual maintenance costs for bioswales according to New Castle County (NCC, 2005) are as follows:

<b>Table 5. Biofiltration Maintenance Costs</b>			
	<b>Frequency</b>	<b>Unit Cost for Biofiltration</b>	<b>Annual Cost for Biofiltration (10 acres)</b>
<b>Inspection</b>	2 times a year	\$200 per inspection	\$400
<b>Sediment Removal</b>	1 time over 3 years	\$350 per event	\$117
<b>Erosion Repair</b>	1 time over 3 years	\$1,200	\$400
<b>Mowing</b>	10 times a year	Based on 8000 sq ft mowed @ \$300/acre	\$440
<b>Soil Amendments</b>	1 time a year	\$100	\$100
<b>Total Annual Cost</b>			\$1,457.00
<b>Total Cost per Acre</b>			<b>\$145.70</b>

The maintenance costs for biofiltration facilities are \$145.70/acre. Calculating the O&M costs over a 25 year lifespan and adding to construction costs provides a total cost of \$4,695.18/acre.

<b>Table 6. Stormwater BMP Costs</b>					
	<b>Dry Ponds</b>	<b>Wet Ponds</b>	<b>Infiltration Structures</b>	<b>Filtering Practices</b>	<b>Biofiltration</b>
<b>Construction Cost /acre</b>	\$2,982.00	\$2,982.00	\$8,946.67	\$13,083.31	\$1,052.68
<b>Maintenance Cost /acre</b>	\$600.50	\$441.50	\$842.75	\$1,301.00	\$145.70
<b>Annual Maintenance/ acre over a 25 year lifespan</b>	\$15,012.50	\$11,037.50	\$21,068.75	\$32,505.00	\$3,642.50
<b>Total Cost/acre</b>	<b>\$17,994.50</b>	<b>\$14,019.50</b>	<b>\$30,015.42</b>	<b>\$45,608.31</b>	<b>\$4,695.18</b>



### **Open Space Cost Calculations**

The costs of the following open space practices have been estimated using data gathered by DNREC's Division of Fish and Wildlife staff. These are estimates, as costs for specific projects may vary.

#### **I. Grassed Open Space**

For municipalities and counties to restrict development in grassed open space as part of their development process, it is estimated that it costs \$400/acre (personal communication, 2009). With a lifespan of 25 years and average maintenance costs of \$35.00/acre/year, the total cost of implementation is \$1,275/acre.

#### **II. Riparian Buffers**

For municipalities and counties to restrict development in riparian buffer areas as part of their development process, it is estimated that it costs \$450/acre (personal communication, 2009). With a lifespan of 25 years and average maintenance costs of \$84.00 /acre/year, the total cost of implementation is \$2,550/acre.

### **Agriculture BMP Cost Calculations**

The costs of the following agricultural BMPs have been estimated using data gathered by the United States Department of Agriculture (USDA) Natural Resources & Conservation Service (NRCS) staff at the county and state level. These are estimates, as costs for specific projects may vary.

#### **I. Cover Crops**

NRCS staff report that the cost of installing cover crops is \$49.33/acre. With a lifespan of a year and maintenance costs of \$5/acre/year, it costs a total of \$54.33/acre to implement. The USDA-NRCS has a cost share program through EQIP for cover crops that covers \$37/acre whereas the New Castle Conservation District (NCCD) runs the state cost share program with funding of \$50/acre.

#### **II. Ponds**

Ponds have an installation cost of \$3,758.50/acre and a lifespan of 10 years with maintenance costs of \$5/acre/year. This provides a total cost of \$3,808.50/acre to implement. Cost sharing levels of capital costs include 50% of the costs with a maximum of \$4,500 from the NCCD.

#### **III. Grassed Waterways**

Grassed waterways cost approximately \$16,404.24/acre to install. With a lifespan of 10 years and maintenance costs of \$5/acre/year, it costs a total of \$16,454.24/acre. Capital costs are cost shared by the USDA-NRCS through the CRP at 50% the cost and EQIP program at \$12,303.18/acre while the New Castle Conservation District cost shares at 75%.

#### **IV. Grass Filter Strips/Wildlife Habitat**

These practices are estimated to cost \$495.24/acre for installation. This practice has a lifespan of 10 years with maintenance costs of \$5/acre/year. Thus, total costs equal \$545.24/acre. The installation of these BMPs are cost shared by the USDA-NRCS through the CRP and CREP programs at 50% and through the EQIP and WHIP program at a rate of \$371.43/acre. The New Castle Conservation District cost shares these practices at a rate of 75% for EQIP practices and 37.5% for CREP practices.

#### **V. Forested Buffers/Riparian Buffers**

The cost of installing a forested buffer is \$495.24/acre with a lifespan of 10 years and maintenance equaling \$5/acre/year. The cost installing a riparian buffer is \$502/acre with a lifespan of 10 years and maintenance equaling \$5/acre/year. The total cost of forested buffers equals \$535.24/acre and the total cost of riparian buffers equals \$552/acre. The installation of forested buffers are cost shared by the USDA-NRCS

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through the CREP program at 50% and through the WHIP program at a rate of \$371.43/acre. The New Castle Conservation District cost shares forested buffers at a rate of 75% for WHIP practices and 37.5% for CREP practices. The installation of riparian buffers are cost shared by the USDA-NRCS through the CREP and CRP programs at 50% and through the WHIP program at a rate of \$376.50/acre. The New Castle Conservation District cost shares riparian buffers at a rate of 75% for WHIP practices and 37.5% for CREP practices.

### VI. **Wetland Restoration**

Wetland restoration costs \$4,374.50/acre. This practice has a lifespan of 10 years and maintenance equaling \$5/acre/year. Thus, the total cost of the wetland restoration equals \$4,424.50/acre. The installation of wetlands are cost shared by the USDA-NRCS through the CRP and CREP programs at 50% and through the WHIP program at a rate of \$3,280.88/acre. The New Castle Conservation District cost shares wetlands at a rate of 75% for WHIP practices and 37.5% for CREP practices.

### VII. **Field Border**

Field borders cost \$495.24/acre with a lifespan of 10 years and maintenance of \$5/acre/year. This equals a total cost of implementation of \$545.24/acre. The USDA-NRCS cost shares field borders through the EQIP and WHIP programs at a cost share rate of \$215.18/acre and the New Castle Conservation District at a rate of 75%.

### VIII. **Critical Area Planting**

The cost of installing critical area plantings equals \$7,229.24/acre. When maintenance of \$5/acre/year is added over a 10 year lifespan, the total cost of this practice is \$7,279.24/acre. The USDA-NRCS cost shares field borders through the EQIP program at a cost share rate of \$5,421.93/acre and the New Castle Conservation District at a rate of 75%.

### IX. **Conservation Tillage**

Implementing conservation tillage costs \$17.33/acre and has a lifespan of 4 years with \$5/acre/year of maintenance. This equals a total cost of \$37.33/acre. The USDA-NRCS cost shares conservation tillage at a rate of \$13/acre.

### X. **Nutrient Management Plans (NMPs)**

The cost to develop a nutrient management plan decreases as the acreage in the plan increases. A three year plan for an operation with less than 500 acres costs \$5.70 which is the size of the majority of farms in the Appoquinimink watershed.

<b>Table 3. Agriculture BMP Costs</b>				
	<b>Installation Cost / Acre</b>	<b>Lifespan (years)</b>	<b>Total Maintenance Costs over Lifespan</b>	<b>Total Costs/ Acre</b>
<b>Cover Crops</b>	\$49.33	1	\$5	\$54.33
<b>Ponds</b>	\$3,758.50	10	\$5	\$3,808.50
<b>Grassed Waterways</b>	\$16,404.24	10	\$5	\$16,454.24
<b>Filter Strips/Wildlife Habitat</b>	\$495.24	10	\$5	\$545.24
<b>Forest Buffers</b>	\$495.24	10	\$5	\$545.24
<b>Riparian Buffers</b>	\$502.00	10	\$5	\$552.00
<b>Wetland Restoration</b>	\$4,374.50	10	\$5	\$4,424.50
<b>Field Border</b>	\$495.24	10	\$5	\$545.24
<b>Critical Area Planting</b>	\$7,229.24	10	\$5	\$7,279.24
<b>Conservation Tillage</b>	\$17.33	4	\$5	\$37.33
<b>NMP</b>	\$5.70	1	-	\$5.70

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